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Approach to chest trauma management in emergency department: Systematic review

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ABSTRACT

Background: Over 10% of all injuries treated in emergency departments are thoracic traumas, with over 70% of these instances being blunt thoracic trauma. In this study, we aimed to systematically review articles discussing the management of chest trauma in the emergency department. **Method:** This systematic review complied with the PRISMA statement. After searching the databases of Medline, Embase, PubMed, and CINAHL for pertinent publications published between 2012 and 2024, we included 5 RCTs, 3 observational studies, and 1 case-control study. **Results:** Immediate care intervention for blunt thoracic injuries was covered by 4 articles in our review. Empyema rates following insertion of a chest drain, ICU need for admission, mortality, and hospital and, ICU LOS were the outcome measures taken by the 4 studies. Standardized formal training for resident medical professionals was the intervention used. Five publications covered the management of multiple rib fractures following chest trauma. Three randomized controlled trials included patients with flail segment and clinical flail chest; one study included patients with flail segment but no flail chest; and one research included individuals with simple rib fractures but no clinical or radiological flail chest. **Conclusion:** Surgical stabilization of multiple rib fractures reduced the duration of mechanical ventilation and the incidence of pneumonia compared with conservative care, but there was no clear improvement in mortality. The length of hospital and intensive care unit stays, as well as empyema incidences, significantly decreased following the adoption of patient pathway-based intervention for medical staff in the emergency department.

Keywords: Chest trauma, emergency department, management, systematic review

1. INTRODUCTION

Thoracic traumas account for 10% to 15% of all injuries treated in emergency rooms, with blunt thoracic trauma making up about 70% of these cases (Sirmali et

al., 2003). Hospital admission is necessary for patients who have had forceful thoracic trauma and pulmonary consequences such as pneumothorax, hemothorax, hemo-pneumothorax, or pulmonary contusions. It is safe to release other patients who have two or fewer isolated rib fractures in isolated blunt thoracic trauma, which is defined as the absence of pulmonary problems and a low risk of their manifestation later (Flagel et al., 2005). A considerable percentage of patients with isolated blunt thoracic trauma, on the other hand, have one or more isolated rib fractures, a sternal fracture, one or more pulmonary contusions, or pneumothorax, and they are thus at high risk of developing pulmonary complications.

For blunt and penetrating traumatic chest injuries, the typical pleural decompression and drainage procedure is intercostal catheter insertion, also known as tube thoracostomy. The technique carries a potential risk of significant complication rates; in certain circumstances, the literature reports as high as 20–30% (Menger et al., 2012). Visceral or neurovascular bundle injuries resulting from insertion and improper placement, such as extra-thoracic implantation, inadequate positioning necessitating re-insertion, wound tract infections, and empyema are among the complications. It has been demonstrated that a number of variables, such as polytrauma, hypotension, mechanical breathing, and pre-hospital placement, raise the risk of complications (Lee et al., 2010). Complications may also result from inadequate training provided to resident medical professionals (Ball et al., 2007). Ball et al., (2007) reported a 28% patient complication rate from a retrospective analysis of resident medical personnel at a level 1 Trauma Centre about problems following the insertion of ICC.

Despite the fact that most resident medical staff members (72%) had completed an Advanced Trauma Life Support course, the high rate of complications indicated that systems-based interventions may also be necessary in addition to enhanced training in order to lower complication rates. A flail chest, characterized by paradoxical movement of the chest wall, altered respiratory mechanics, and often respiratory failure, is one of the hallmark clinical signs. Due to the paradoxical movement of the flail segment, these injuries have a high frequency of sequelae, such as LOSs of lung capacity, chest wall instability, and severe pulmonary limitation, which have made pain management in general difficult (Lee et al., 2010). Pain, reduced lung capacity, and unstable chest walls can all combine to cause reduced lung function and the requirement for continuous ventilation. Our goal in conducting this study was to thoroughly analyze publications that addressed chest trauma care in ER settings.

2. METHOD

The PRISMA declaration Liberati et al., (2009) was adhered to in this systematic review. This evaluation set out to investigate the emergency department's approach to treating chest trauma. RCTs, observational studies, and case-control studies that addressed the emergency department's approach to treating chest trauma were included. The following categories of articles were not included in the analysis: Editorials, case reports, expert comments, narrative reviews, and research using experimental animals. Medline, Embase, PubMed, and CINAHL databases were searched for relevant articles published in the period from 2012 to 2024, we included 5 RCTs, 3 observational and 1 case-control study that enrolled adult patients suffering from chest trauma, the following search terms were used (thoracic injuries, trauma, rib fractures, flail chest, pathway, costal fracture, guideline, integrated care, care bundle, complications, analgesia, length of stay, mortality, respiratory support, intensive care, and implementation).

A number of parameters were specified, such as mortality, length of stay in hospitals and critical care units, length of time on mechanical ventilation, rates of complications and ventilator support needs, demand for tracheostomy, and frequency of pneumonia. Duplicates were eliminated and citations were kept. All authors separately reviewed the studies first based on abstract and title; those that didn't fit the requirements were eliminated. If needed, disagreements were settled through conversation. Following this preliminary phase, the whole texts of all subsequent research were examined, and discrepancies were settled using the same methodology as the first screening.

A PRISMA flow diagram was used to record the study selection procedure (Figure 1). The authors separately extracted the study characteristics from each included study and converted the data into a format unique to that study. The data shown below was taken from the included research: Citation, location, study setting, study design, sample size, interventions, participant characteristics, outcome measures, and main findings. Data that support the findings of this study are embedded within the manuscript.

3. RESULTS

A total of 364 articles were collected from databases; after duplication removal, 298 remained, which were screened for title and abstract, leaving 43 full-text articles assessed for eligibility, and finally, 9 studies were included in the review (Figure 1). Four papers in our analysis addressed immediate care intervention for blunt thoracic injuries: One retrospective case-control study and three observational retrospective studies. The four trials' outcomes included mortality, ICU need for admission, hospital, and ICU LOS, and empyema rates after chest drain installation. The remedy employed was standardized formal training for resident medical professionals. A total of 578 patients were included in five papers concerning the management of multiple rib fractures resulting from chest trauma.

According to 2015 Australian research by Anderson et al., (2015) practice relating to the insertion, maintenance, and removal of chest tubes and chest drainage systems became more consistent following the adoption of standardized standards. It focused on practices including aseptic procedures, the use of prophylactic IV antibiotics on insertion, and regular monitoring and evaluation on the ward, and were based on the data that was available. The percentage of empyema dropped from 1.44% to 0.57% ($p = 0.038$) (Table 1). According to Gonzalez et al., (2015) study, six factors—low albumin, chronic obstructive lung disease, assisted status, Injury Severity Score, and tube thoracostomy—increased the likelihood of intubation or pneumonia. A prediction model was developed using congestive heart failure and these six factors.

The sensitivity and specificity for a score below 3.7 were 78.5% and 78.9%, respectively. Menditto et al., (2012) study found that in the pre-EDOU era, 12% of the patients treated were readmitted to the ED; however, during the EDOU period, only 4% of the patients experienced readmissions (p -value 0.03). Following the installation of the EDOU, the tube thoracostomy rate done on admitted patients increased considerably from 12.5% to 1.9%. Hospital stays were lengthier in the period pre-EDOU than they were in the period of EDOU, and the hospitalization rate dropped from 49% in the former to 24% in the latter. Cost analysis was conducted both before and during the EDOU period and found no discernible difference in patient cost-effectiveness. The 2017 study by Carrie et al., (2018) sought to evaluate the efficacy of a multidisciplinary treatment route for patients with acute chest injuries who were brought to the emergency room.

All consecutive patients with acute chest trauma who had more than three rib fractures with no sign of assisted respiration were compared to a cohort over a 24-month period, both before and after the implementation of the care package. A multimodal therapeutic approach significantly improves pain management after ED treatment, but it increases the likelihood of first ICU admission without significantly reducing the frequency of recurrent respiratory issues. Regarding the multiple rib fractures management following chest trauma, 5 articles were included with a total of 578 patients (Table 2). Patients with flail segment and clinical flail chest were included in three RCTs Dehghan et al., (2022), Liu et al., (2019), Marasco et al., (2022), patients with flail segment but no clinical flail chest were included in one study Meyer et al., (2023), and patients with simple fractures and no clinical or radiological flail chest were included in one research (Pieracci et al., 2020) (Table 3).

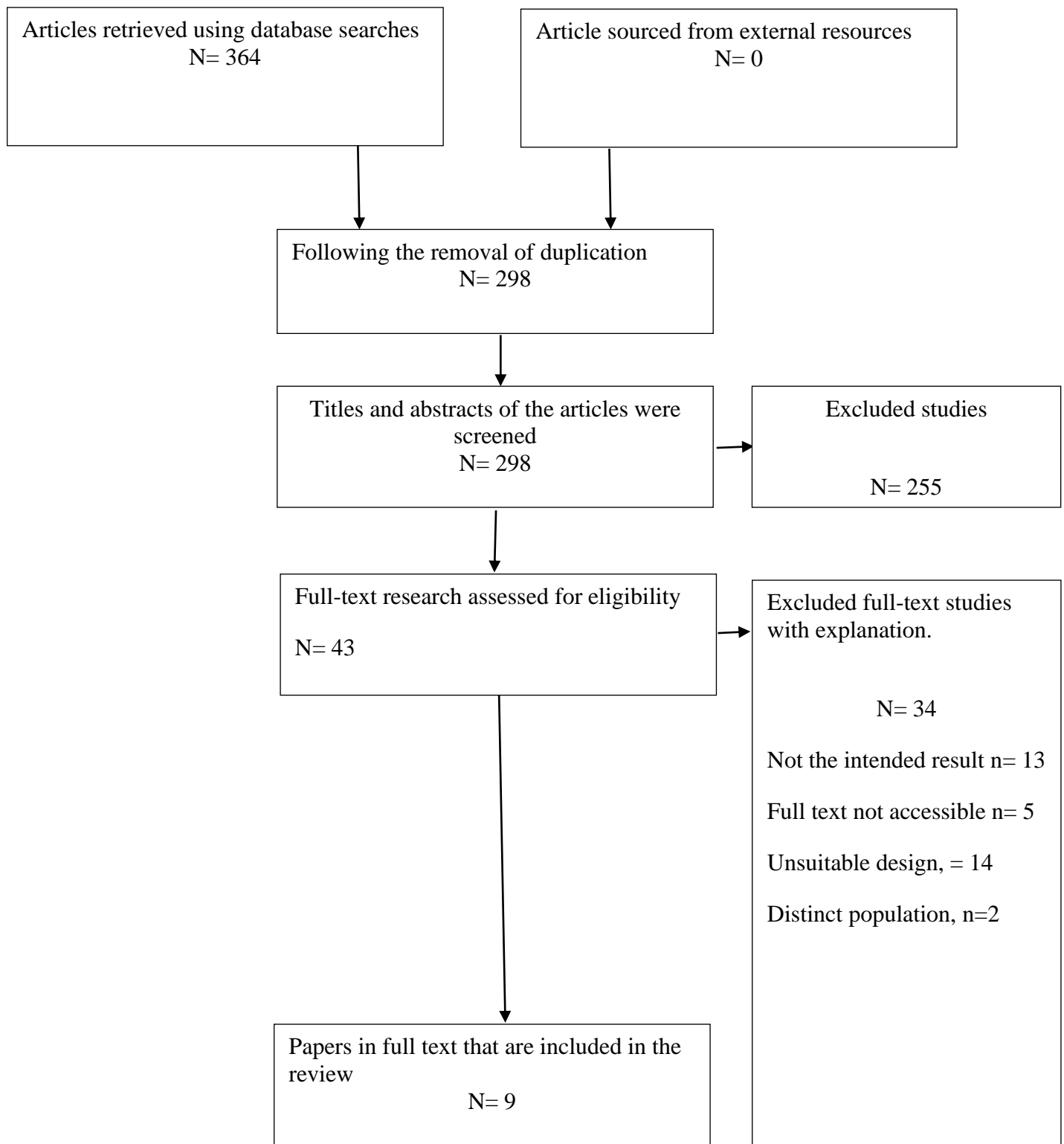


Figure 1 PRISMA consort chart

Table 1 Articles addressed immediate care intervention for blunt thoracic injuries

Citation	Location	Study setting	Study design	Sample Size:	Intervention	Outcome Measures	Main findings
Anderson et al., 2015	Australia	Emergency Department	Observational Retrospective Study	4129	Standardized formal training for resident medical professionals and an evidence-based checklist procedure for inserting intercostal catheter	Empyema rates following insertion of chest drain	Empyema pre-protocol incidence was 1.44%. After the protocol, the incidence of empyema was 0.57 p = 0.038.
Gonzalez et al., 2015	USA	Emergency Department	Observational Retrospective Study	400	Predictive model and Blunt Thoracic Injury Pathway Development for Identification for high risk groups requiring ICU in Blunt Thoracic Injury care	ICU need for admission	The average length of ICU stay was 1.7 days. The following factors were predictive of an ICU stay: low albumin, number of rib fractures, COPD, and ICD. A risk score with a specificity (78.9%) and sensitivity (78.5%) was generated using these factors.
Menditto et al., 2012	Italy	Emergency Department	Observational Retrospective Study	240	Clinical Pathway and decision-making protocol	Mortality, ICD rate for postponed hemothorax, 30-day readmission, and hospital LOS.	Lower hospitalization rates, lower re-admission rates, higher rates of late ICD, and lower hospital

							LOS.
Carrie et al., 2018	France	Emergency Department	Retrospective Case Control Study	138	Clinical pathway and care bundle comprising: oxygenation and identification, analgesia, breathing support, deterioration, and chest drain management.	Rate of unmanaged pain in the first twenty-four hours after admission, Complications, Pulmonary Rate, Hospital LOS, ICU LOS, Opioid Use, Pain at Rest.	Decrease in the percentage of uncontrolled analgesia. higher ICU admission rate. There is no change in the rates of hospital LOS, or pulmonary complications. The use of NSAIDs may lower the incidence of respiratory problems.

Table 2 Articles covered the treatment of numerous rib fractures after chest trauma.

Citation	Number of patients	Primary outcome	Mean age	ISS score (mean)	Number of fractures (mean)
Meyer et al., 2023	84	Hospital stay duration	49.5	22.5	8
Dehghan et al., 2022	207	Ventilator-free days	53	25.6	10.3
Marasco et al., 2022	124	Pain	57	15.3	6.7
Pieracci et al., 2020	110	Pain	54.9	13.5	7
Liu et al., 2019	53	Mortality	40.6	28.3	5.65

Table 3 Method and main findings of articles covered the treatment of numerous rib fractures after chest trauma.

Citation	Type of fracture	Method	Main findings
Meyer et al., 2023	Clinical flail chest, flail segment	The authors looked at severely injured individuals with flail chests who were brought to different trauma centres. Random assignment placed the recruited patients in either the surgery or nonsurgical group. Basic damage features and clinical results were contrasted.	A total of fifty patients—25 in each group—were analyzed. A shorter length of time on mechanical ventilation, a shorter stay in the ICU, a decreased risk of ARDS, pneumonia, and thoracic deformity, as well as reduced pain during deep breathing and coughing, have all been linked to surgical rib fixation. A subgroup analysis based on the existence of pulmonary contusion was carried out. In pulmonary contusion patients, shorter ICU stays and shorter times on the ventilator were not seen. This was related to rib

			surgery.
Dehghan et al., 2022	Simple rib fractures	A prospective controlled study comparing medicinal care with SSRF administered within 72 hours. At the patient's decision, there were randomized and observational arms to the experiment. At the 2-week follow-up, the primary outcome was the numerical pain score. A comparison was also made between narcotic intake, spirometry, pulmonary function tests, pleural space issues, and quality of life in general and in relation to respiratory disabilities.	Patients who were randomized vs observation did not significantly vary from one another; hence, these groups were mixed for all analyses. 46.4% of the 110 individuals had SSRF. The operational and nonoperative groups did not differ at all from their baseline conditions. When compared to the nonoperative group, the operation group's NPS was much lower at the 2-week follow-up, and their quality of life had greatly improved. The operational group's usage of narcotics also showed a tendency towards being lower than that of the nonoperative group. Pleural space problems during the index hospitalization were considerably fewer in the surgical group than in the nonoperative group.
Marasco et al., 2022	Clinical flail chest, flail segment	In a prospective multicenter randomized controlled study, patients with at least three consecutive rib fractures were compared between non-operative treatment and rib fixation. Displacement of the ribs or persistent discomfort were requirements for inclusion. Three and six months after the injury, pain and quality of life were evaluated. Patients who the surgeons believed to have clinical equipoise were included. No patients were included if it was determined they required surgical fixing or if they were healthy to be randomly assigned to rib fixation.	A total of 61 patients were randomly assigned to receive surgical care, and 63 to receive non-operative care. There were no differences seen in the QoL measures or the primary endpoint of the Pain Rating Index at three months. Between three and six months, return-to-work rates increased, with the surgical group benefiting.
Pieracci et al., 2020	Clinical flail chest, flail segment	This was a randomized and prospective study. Patients between the ages of 16 and 85 who had significant chest wall deformities and displaced rib fractures with a flail chest or non-flail chest injuries met the inclusion criteria. Patients who met the exclusion criteria included those medically unsuitable for surgery, those with serious additional injuries that would necessitate continuous mechanical respiration, and those randomly allocated to research groups after 72 hours of injury.	The analysis comprised 207 patients in total (108 patients were in the operative group and 99 patients were in the non-operative group). The operative group's mean number of days without a ventilator was 22.7, whereas the non-operative group's was 20.6. Compared to the operative group, the non-operative group's mortality rate was much greater. The length of stay and the rate of complications were comparable among the groups. Patients who were on mechanical ventilation at the time of randomization showed a mean difference of 2.8 ventilator-

			free days in favor of surgical therapy, according to subgroup analysis.
Liu et al., 2019	Flail segment only	This randomized controlled study compared SSRF versus nonoperative care for ≥5 consecutive rib fractures, any rib fracture with bicortical displacement, or a radiographic flail segment without clinical flail. The unit of admission was used to stratify the randomization process as a stand-in for injury severity. Hospital LOS was the principal outcome. The following were secondary outcomes: Ventilator days, mortality, opioid exposure, ICU length of stay, tracheostomy, and pneumonia.	The frequency of displacement fractures and radiological flail segments, as well as the total, displaced, and segmental fractures per patient, were comparable. Hospital LOS was higher in the SSRF group. Ventilator days and ICU LOS were comparable. Hospital LOS was still higher in the SSRF group even after controlling for the stratification variable, and ventilator days stayed the same.

4. DISCUSSION

We included nine full-text papers in our review. Four publications in our study addressed immediate treatment intervention for blunt thoracic injuries. A total of 578 patients were included in five papers covering the management of multiple rib fractures resulting from chest trauma. The majority of pathway-based therapies that have been documented in the review were created by means of an evaluation of the available data or expert opinion. The research doesn't seem to agree on the best strategy for developing pathways, but it is clear that similar to other complex treatments, pathways must be constructed and assessed using a methodical theoretical framework. The Medical Research Council framework is a widely used strategy for developing and evaluating complicated therapies; however, it isn't mentioned directly in any of the publications examined (Moore et al., 2015; O'Cathain et al., 2019). Strong development techniques must come before and support efficient assessment procedures, even if this systematic review did not specifically address the pathway creation process.

Numerous patient pathway-based treatments were shown to be related to lower hospital and ICU stay duration in this study. This conclusion is congruent with the results of clinical pathway assessments in other complex healthcare settings, despite the fact that it was not consistent across all included research (Anderson et al., 2015; Gonzalez et al., 2015; Menditto et al., 2012; Carrie et al., 2018). In a similar vein, the effects of prolonged ICU stay have been extensively studied in the literature Evans et al., (2018), Moitra et al., (2016), and the factors influencing ICU stay duration are numerous and intricate (Almashrafi et al., 2016). Despite these findings, it's crucial to keep in mind that delayed discharge confounds ICU stay duration and is frequently caused by a shortage of acute care beds when patients are supposed to be released four hours after a discharge decision is made (Gilligan, 2017). Similar to this, the availability of beds in long-term care facilities confuses this indicator in the US (Johnson et al., 2013). To account for this possible artifact, more thorough techniques must be used when assessing any patient pathway-based strategy for the treatment of traumatic thoracic injuries.

Five studies about the management of multiple rib fractures following chest trauma were included in our investigation. In comparison to patients receiving conservative treatment, our study showed that multiple rib fractures patients who underwent surgical procedures experienced significant clinical benefits, such as quicker weaning off the mechanical ventilator, a lower pneumonia incidence, and a shorter ICU stay duration. In recent years, a large number of RCTs have been published (Meyer et al., 2023; Dehghan et al., 2022; Marasco et al., 2022; Pieracci et al., 2020; Liu et al., 2019). Most of these RCTs have shown no differences in mortality. One of the main causes of death for individuals with thoracic injuries is pneumonia. Prior RCT that preceded Dehghan et al., (2022) research documented a noteworthy decrease in the pneumonia incidence among the group of surgical intervention in contrast to the group of conservative management. This discovery aligned with other systematic reviews and meta-analyses' conclusions (Liu et al., 2019; Ingoe et al., 2019).

However, recent RCTs done over the past few years, for example, Meyer et al., (2023), and Dehghan et al., (2022) studies, didn't demonstrate discernible variation in the frequency of pneumonia across the groups. Notably, the non-operative treatment group in these new RCTs was given known procedures, such as those for weaning strategies, meticulous care, and epidural anesthesia. Before

being included in the research, every patient in RCTs covering multiple rib fracture management was originally receiving mechanical ventilation. Multiple rib fracture patients may benefit from surgery, especially those who require artificial breathing upon arrival. According to our review results, there is sufficient evidence to support the advantage of surgical therapy.

5. CONCLUSION

After the implementation of standardized formal training, predictive model, blunt thoracic injury pathway, and decision-making protocol for medical professionals in the emergency department, the incidents of empyema, hospital, and ICU stay duration considerably decreased. When compared to conservative therapy, surgical stabilization of multiple rib fractures resulted in shorter periods of mechanical ventilation and a lower incidence of pneumonia, but there was no conclusive indication that mortality was improved.

Abbreviations

ICT: Intercostal tube

ICD: Intercostal Drain

LOS: Length of stay

ICU: Intensive care unit

SSRF: Surgical stabilization of rib fracture

NPS: Numeric pain score

RCTs: Randomised controlled trials

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Ethical approval

Not applicable

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This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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